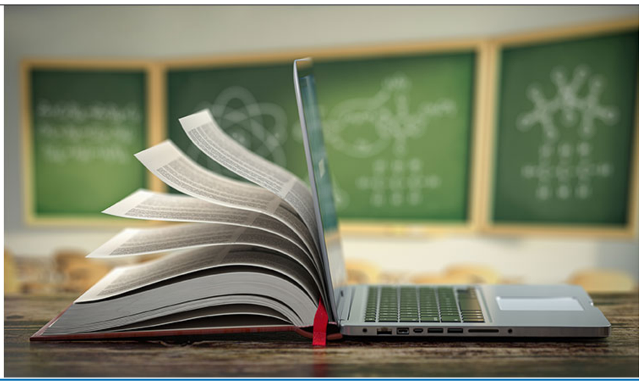
PAPER • OPEN ACCESS

Improving the technology installation of slabs of jointless ossature without girders and joints of KUB system civic buildings

To cite this article: N I Fomin *et al* 2020 *IOP Conf. Ser.: Mater. Sci. Eng.* **972** 012043



Improving the technology installation of slabs of jointless ossature without girders and joints of KUB system civic buildings

N I Fomin[1], K V Berngardt [1], A V Vorobiyov[1], E E Zoteeva [1]

[1]Ural Federal University, 19 Mira str., Ekaterinburg, 620002, Russia

E-mail: ni.fomin@urfu.ru, kv.berngardt@urfu.ru, zoteeva@outlook.com

Abstract. According to the research results of precast and cast-in-situ civil buildings construction, made in KUB constructive system (cross-functional jointless ossature without girders and joints) in the Middle Urals conditions, the need to develop a technologically advanced method for the installation of the column floor slab, as well as erection device for its implementation is identified. While developing a new design and technological solution, methodological means were used (identifying contradictions, methods of eliminating them) of the theory of solving inventive problems (TRIZ). As a result of inventive activity, a mounting method of the column slab of girderless floor construction in KUB system and a mounting device for its implementation has been proposed.

1. Introduction

During the technical survey of unfinished residential building structures of KUB system (Pervouralsk, Sverdlovsk region), as well as erecting process studies of girderless floor construction, contained in this structural system, it was found that the technological reliability of installation process of the column slab is insufficient. The results obtained are consistent with the data of a number of studies [1-3], which emphasize the importance of a quality device for connecting columns and floor without beams. This node point is the most vulnerable place of the frame by the mounting structures criterion. The existing low level of technological reliability is due to the fact, that the known method of floor slab mounting, provided by the series on the jointless ossature without girders and joints KUB-2,5, as well as its modifications (KUB-3V, etc.), includes the sequential installation of two mounting devices: conductor and cleat. These devices provide separately the adjustment of the slab in the plan (conductor) and height (cleat). Adjusting the slab position vertically is carried out by cleat support rods, which have no connection with each other. The main disadvantages of the existing method of installation should be considered: the need to use two mounting devices for slab aligning in the plan and in height; the high labor intensity of the adjustment of the slab over height (small areas of base platform of the adjusting elements (rods) do not allow smooth and precise adjustment). Thus, the need to develop a new method of installation of a column slab and erection device for its implementation has been revealed. The development of new design and technology solutions in the construction field can be carried out by solving the formulated inventive problem, using the methodological tools of the theory of inventive problem solving (TRIZ).

2. Raising and resolution of the inventive issue by the TRIZ method

In 1950-1980 Russian researcher and inventor G.S. Altshuller created the methodical basis of the classical theory of solving inventive problems. The backbone of TRIZ can be described quite generally as follows: in a problem situation, technical contradictions are consistently identified, which are eliminated with the help of a number of special techniques [4-6]. Using terminology ModernTRIZ (MTRIZ) – the modern direction of development of the theory created by the Russian scientist M.A. Orloff [7, 8], the process of solving an inventive problem can be divided into three main stages.

Stage 1. Trend. Identify shortcomings in the existing solution and determine the course of changes. The main disadvantages of the existing solution: the need to use two mounting devices for slab alignment in the plan and in height; low technological reliability, which leads to a high labor intensity of the height adjustment of the floor slab (small areas of base platforms of the adjusting elements do not allow smooth and precise adjustment). The statement of a question: How to make the process of floor slab mounting technologically reliable? Goal setting: to improve the process of floor slab mounting.

Stage 2. Reduction. Establish technical contradictions that are the causes of previously identified deficiencies. Contradictions elimination in the future will allow achieving the goal set above. At this stage, the table of choice of methods for eliminating technical contradictions (A-matrix) and a table of basic techniques for eliminating technical inconsistencies (Ac- catalog) are applied. Two variants of contradictions and methods for their elimination are defined.

Option 1.Question 1.1: What needs to be changed under the conditions of the problem? Answer 1.1: Reliability (system parameter No 27). Question1.2: What gets worse while changing? Answer 1.2: Serviceability (system parameter No 33). Recommended numbers of methods for eliminating technical contradictions according to the selection table: 27, 17, 40.

Technique No 17. The principle of transition to another dimension: the difficulties associated with the movement (or object placement) are eliminated on the line if the object **gets the ability to move in two dimensions**, i.e. on the surface). – This technique can be applied to solve the formulated problem.

Technique No 27. Cheap fragility instead of inexpensive durability: replace an expensive object with a set of cheap objects, sacrificing some qualities (durability, for example). This technique is not applicable to the solution of the formulated problem.

Technique No 40 Use of composite materials: proceed from homogeneous to composite materials. This technique is not applicable to the solution of the formulated problem.

The resulting solution can be summarized as follows: **27**. Reliability (+) **VS 33**. Serviceability (-) = **17**. The principle of another dimension transition.

Option 2. Question 2.1: «What needs to be changed under the conditions of the problem? ». Answer 2.1: Ease of manufacturing (system parameter No 32). Question 2.2: What gets worse while changing? Answer: Device complexity (system parameter No 36). Recommended numbers of methods for eliminating technical contradictions according to the selection table: 27, 26, 1.

Technique No 27. Cheap fragility instead of inexpensive durability: replace an expensive object with a set of cheap objects, sacrificing some qualities (durability, for example). This technique is not applicable to the solution of the formulated problem.

Technique No 26. Copying principle: instead of an inaccessible, complex, expensive, inconvenient, etc. object, use its simplified copies; replace an object or system of objects with their optical copies; if visible optical copies are used, switch to infrared or ultraviolet copies. This technique is not applicable to the solution of the formulated problem.

Technique No 1. Fragmentation principle: divide the object into independent parts; **make object collapsible**; increase the fragmentation degree of the object. This technique can be applied to solve the formulated problem.

The resulting solution can be summarized as follows: **32**. Ease of manufacturing (+) **VS 36**. Device complexity (-) = **1**. Fragmentation principle.

Stage 3. Invention. Key ideas: to provide the possibility of simultaneous adjustment of the position of the floor slab in the plan and in height with a single mounting device consisting of two symmetrical blocks, by combining two existing devices: a cleat and a conductor; to increase the contact area of the adjusting elements of the mounting fixture (use adjusting plates instead of adjusting rods).

Based on the obtained solution of the inventive problem, a method of installation and an assembly device for the installation of the column slab has been developed.

3. Method of installation and erection device for the installation of the column slab

The method of the column slab mounting includes mounting the slab on the erection device attached to the column with stretching screw. While the edges of the hole in the column slab are aligned with the outer edges of the centering plates of the erection device and adjust the position of the slab in height along its four sections, using adjustment screws on the beams of the erection device, with the subsequent implementation of the design connection of the column slab and the column.

The proposed erection device is made of two symmetric blocks, with the possibility of bolting, and temporary fixation by stretching screw. Each block contains a beam with two adjusting screws, as well as at least three centering plates rigidly attached to the top of the beam.

Two sets of erection device are temporarily fixed to the column with stretching screw. When blocks are fixed, the centering plates form a closed boundary around the perimeter of the column, with the same gap between the outer faces of the centering plates and the faces of the column.

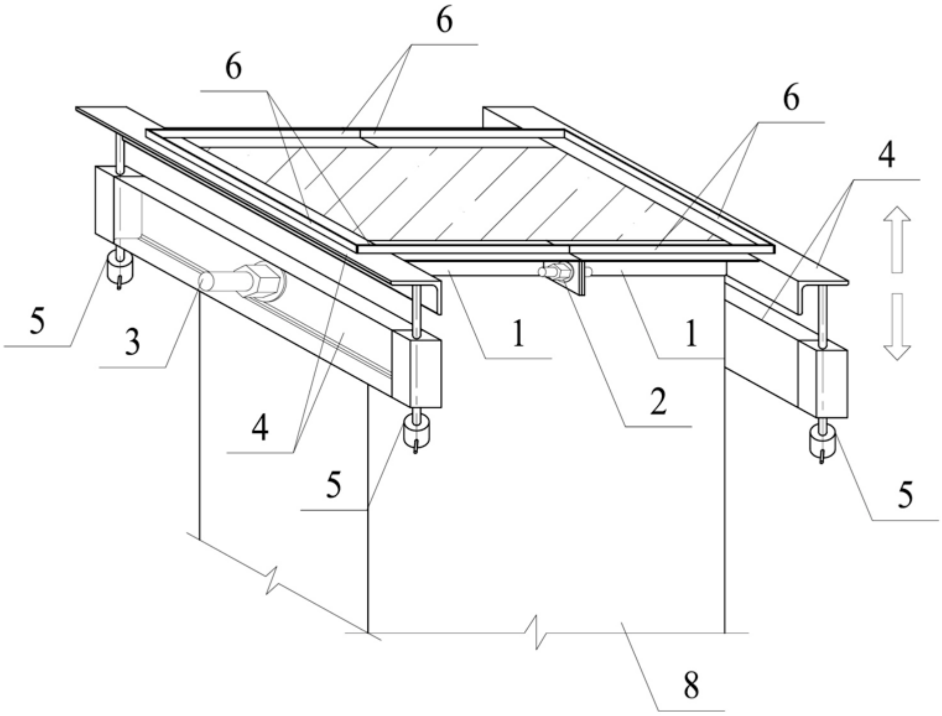
At the end of these works and the connection design of the column slab and the column, including the set of necessary concrete strength, the erection device is dismantled. In order to do this, it is necessary to unscrew the stretching screw and separate the blocks of the device.

While performing technical operations according to the proposed technique, as well as using the developed erection device, it is possible to increase the technological reliability of the installation process of the column floor slab as follows:

- significant reduction in the complexity of the floor slab alignment in height, including the uneven surface of the slab, due to the presence of beams with adjusting screws;
- significant reduction in the complexity of the floor slab alignment plan (horizontally), due to the presence of centering plates, rigidly fixed to the beams, which provide forced alignment of the slab horizontally (centering of the slab towards the column);
- ensuring the possibility of technological installation and fixation of erection device due to the presence of symmetric blocks, with the possibility of their bolting to each other, as well as the presence of the stretching screw.

In accordance with the recommendations [9, 10], a graphical explanation of the developed method and erection device is presented in the isometric view and characteristic cross-section (Figure).

The patent search, carried out in accordance with the recommendations [11-13], devices solutions for mounting column slab of girderless floor construction in the KUB system did not reveal any analogs with high relevance. Therefore, an application was prepared for obtaining a patent of the Russian Federation for the invention No 2018146398 based on the developed solution.



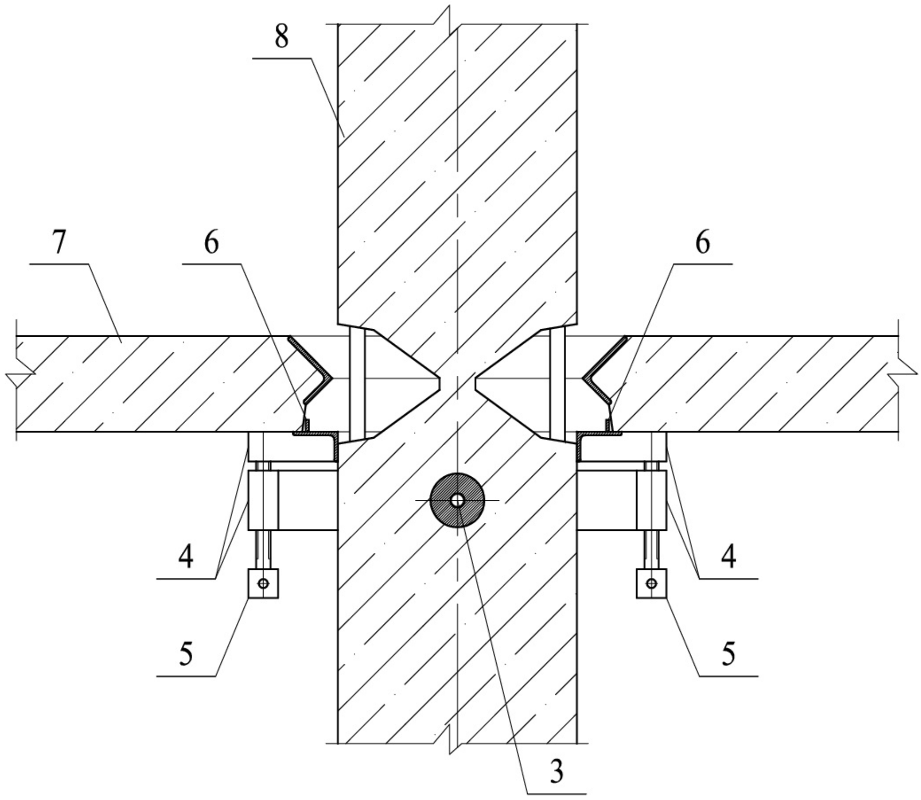


Figure. Erection device:
1 – erection device unit; 2 – bolted connection of erection device blocks; 3 – tierod; 4 – beam; 5 – adjusting screw; 6 – centering plate; 7 – column slab; 8 – column

4. Conclusion

Installation of the column floor slab, provided for a series on jointless ossature without girders and joints KUB-2,5, as well as its modifications (KUB-3V, etc.), is not technologically effective. When using such installation, there is a possibility of technological errors, which can cause a significant deterioration in the performance of load-bearing structures of precast and cast-in-situ building. The use of TRIZ tools allows obtaining new design and technological solutions that eliminate existing shortcomings. The obtained solutions, as a rule, have signs of patentability. According to the results of the research and the solution of the inventive problem with the use of TRIZ tools, a method has been developed: a method for mounting a column floor slab and an erection device for its implementation. The application of the developed method and erection device will allow increasing the technological reliability of the process for assembling a column floor slab of girderless floor construction of the precast and cast-in-situ frame of the KUB system.

References

[1] Elliott K and Jolly C 2013 *Multi-storey Precast Concrete Framed Structures* (London: John Wiley & Sons) 750 p ISBN 978-1-405-10614-6
[2] Elliott K 2016 *Precast Concrete Structures* (London: CRC Press) 732 p ISBN 978-1-498-72399-2
[3] Bachmann H, Steinle A 2011 *Precast Concrete Structures* (Berlin: Ernst & Sohn) 272 p ISBN 978-3-433-02960-2
[4] Chechurin L 2016 *Reseach and Practice of the Theory of Inventive Problem Solving (TRIZ): Linking Creativity, Engineering and Innovation* (New York: Springer) 281 p ISBN 978-3-319-31782-3
[5] Hua Z, Yang J and Coulibaly S 2006 Integration TRIZ with Problem-solving Tools: A Literature Review from 1995 to 2006. 1 (1-2) *International Journal of Business Innovation and Research* pp 111 – 128
[6] Gadd K 2011 *TRIZ for Engineers: Enabling Inventive Problem Solving* (Chichester: John Wiley & Sons. 504 p ISBN 978-0-470-74188-7
[7] Orloff M 2012 *Modern TRIZ: A Practical Course with EASyTRIZ* (Berlin: Springer) 449 p ISBN 978-3-64-225717-4
[8] Orloff M 2006 *Inventive Thinking through TRIZ: A Practical Guide* (Berlin: Springer) 352 p ISBN 978-3-54-033222-0
[9] Pressman D 2015 *How to Make Patent Drawings* (Berkeley: NOLO) 256 p. ISBN 978-1-413-32156-2
[10] Henderson M 2016 *Patent Drawing Rules: Patent Drawing Rules of the United States Patent and Trademark Office and the World Intellectual Property Organization* (Chagrin Falls: Studio 94) 248 p. ISBN 978-0-982-82702-4
[11] Kennedy J and Watkins W 2012 *How to Invent and Protect Your Invention: A Guide to Patents for Scientists and Engineers* (New Jersey: John Willey & Sons) 226 p ISBN 978-1-118-36937-1
[12] Yonover H and Crowe E 2014 *Hardcore Inventing: Invent, Protect, Promote, and Profit from Your Ideas* (New York: Skyhorse) 288 p ISBN 978-1-629-14426-9.
[13] Kannankeril C 2018 *The Inventor in You: A Step-by-Step Guide to Your First Invention* (Bloomington: BalboaPress) 192 p ISBN 978-1-982-20265-1.